Track 7: Spacecraft Avionics Systems & Technologies

Track Organizer: John Samson, Jr., Honeywell Inc.
Track Organizer: Scott Tyson, SES Consultants, Inc.

7.01 Onboard Processing Hardware Architectures and Interconnect Technologies

Session Organizer: Joseph Marshall, BAE SYSTEMS

7.0101 Analysis of a SAE AS5643 Mil-1394b Based High-Speed Avionics Network Architecture

Haowei Bai (Honeywell)

Presentation: Sunday, March 4th, 4:30 pm, Lake/Canyon

To satisfy the increasing needs of more information transmission among subsystems, and to minimize the latency of data transmission between high-speed processors, the avionics interconnection in future aerospace vehicles is required to provide high bandwidth data path. IEEE 1394 was designed as a high speed (up to 3.2 Gbps) data bus for consumer electronics. The Lockheed Martin's Joint Strike Fighter (JSF) program was the first significant implementation of IEEE 1394b for aerospace vehicles. Its approach has been standardized by SAE AS5643. This article is to explain the standard in details and provide insights into it, using failure modes and effects analysis (FMEA) tools. The analysis results and recommendations could be used...

7.0102 Increasing Performance and Removing Bottlenecks in Reconfigurable Space Processing

Joseph Marshall, Jeffrey Robertson (BAE Systems)

Presentation: Sunday, March 4th, 4:55 pm, Lake/Canyon

We describe a new building block under development for reconfigurable systems that marries programmable support circuitry for reconfigurable devices and non-volatile configuration memory into an integrated and expandable building block based on BAE Systems technologies in non-volatile memories and reconfigurable support logic. We discuss the application of this building block, its programming and its insertion into various reconfigurable processing systems. We describe a test board that allows testing of the device elements, demonstration of reconfigurable applications, connections to various interfaces both heritage such as CompactPCI and SpaceWire and new interfaces such as Rocket IO, Rapid IO or PCI Express.

7.02 Onboard Processing Hardware Architectures and Interconnect Technologies

Session Organizer: Edward Prado, Honeywell Inc.
Session Organizer: Stephen Ruggles, NASA Langley Research Center
Session Organizer: Michael Lovellette, Naval Research Laboratory

7.0201 SIFOpt -- Fixed-Point Implementations of Calculations from Floating-Point Descriptions

David M. Buehler, Gregory W. Donohoe (University of Idaho)

Presentation: Sunday, March 4th, 5:20 pm, Lake/Canyon

This paper presents a methodology and a software tool for generating fixed-point computations, enabling integer-only processors to achieve numerical accuracy comparable to floating point with the high speed, small size and low cost of integer hardware. Signal processing and control algorithms are typically designed and modeled in high-level software that uses floating point computations. The program must then be re-written for target hardware, which may be an integer-only microcontroller or DSP chip, or an FPGA or ASIC. This methodology and software provide a systematic synthesis of these integer-only implementations, with accuracy rivaling floating point...

7.0202 SpaceWire Plug 'n' Play

Glenn Rakow (NASA Goddard Space Flight Center); Patrick McGuirk (Micro-RDC); Clifford Kimmery (Honeywell, Inc.); Paul Jaffe (NRL)

Presentation: Sunday, March 4th, 8:50 pm, Lake/Canyon

Advancements in plug-and-play (PnP) technologies for terrestrial applications can serve as a baseline model for a PnP approach for satellite applications. Since SpaceWire (SpW) has become a de facto standard for satellite high-speed (>200Mbp) on-board communications, it has become important for SpW to adapt to this Plug and Play (PnP) environment. Because SpW is simply a bulk transport protocol and lacks built-in PnP features, several changes are required to facilitate PnP with SpW.

7.0203 Radiation Hardened FPGA Technology for Space Applications

Leonard Rockett, Dinu Patel, Steven Danziger (BAE SYSTEMS); Brian Cronquist, J.J. Wang (Actel Corporation)

Presentation: Sunday, March 4th, 9:15 pm, Lake/Canyon

High performance, high density, radiation hardened Field Programmable Gate Arrays (FPGAs) are in great demand for military and space applications to reduce design cost and cycle time. BAE Systems has implemented radiation hardened 150nm bulk CMOS process technology in its foundry located in Manassas, VA to support such advanced product needs. BAE Systems and Actel Corporation are collaborating to bring the next-generation radiation hardened FPGA product for space applications to market. This paper will describe the test results and status of the rad hard RHAX250-S FPGA product installation and qualification effort.

7.0204 Design of Store and Forward Data Collection Low-cost Nanosatellite

Anane Addaim, Abdelhaq Kherras, El Bachir Zantou (Centre for Space Research Studies, Morocco)

Presentation: Sunday, March 4th, 9:40 pm, Lake/Canyon

The satellite, as small as the Cubesat concept, requires employment of limited small boards. In the modular architecture, each single subsystem has a dedicated hardware and software. The approach, which has been taken in this paper, based on two design directives: the integration of the maximum subsystems within the same unit taking into account that single subsystems can be setup without modifying the operation of the remaining subsystems, and the elimination of nonessential elements. In this paper, we will describe in details the design of integrated store-and-forward APRS (Automatic Packet Reporting System) payload and OBDH (On Board Data Handling) subsystems.

7.03 Onboard Memory and Data Storage Technologies

Session Organizer: Craig Hafer, Aeroflex Colorado Springs
Session Organizer: Murty Polavarapu, BAE Systems

7.0301 A Radiation Hardened 16-Mb SRAM for Space Applications

Tri Hoang (BAE Systems)

Presentation: Monday, March 5th, 8:30 am, Lake/Canyon

A new high density, high performance 16-Mb Static Random Access memory (SRAM) is being developed in a 0.15µm CMOS RH15 technology for use in space and other strategic radiation hardened applications. The SRAM design is implemented in a 1.5 Volt, 0.15 micron, and seven-layer metal CMOS technology. Using integrated process features and advanced design techniques, a small cell size of 9.3µm² was utilized while achieving a SEU radiation hardness of less than 1E-12 upsets/bit-day and a worst-case chip performance of less than 15ns access time.

7.0302 RadHard 16Mbit SRAM Packaged in a Cantilever Die Multi-Chip Module

Craig Hafer, Jonathan Mabra, Duane Slocum, Sean Thorne (Aeroflex Colorado Springs)

Presentation: Monday, March 5th, 8:55 am, Lake/Canyon

Aeroflex Colorado Springs has developed a 16Mbit multi-chip module (MCM) SRAM operating on a single 5V power supply. Using a cantilever die stacking approach, two die are stacked on the top side of the package and two die are stacked on the bottom side of the package for a minimum foot print configuration. Conventional aluminum wire bonding has been used to optimize the reliability of this packaging technique.

7.0303 RadHard 16Mbit Monolithic SRAM for Space Applications

Craig Hafer, Jonathan Mabra, Duane Slocum (Aeroflex Colorado Springs)

Presentation: Monday, March 5th, 9:20 am, Lake/Canyon

A review of Aeroflex Colorado Springs' 16Mbit monolithic SRAM includes the SRAM architecture, a product/process description, radiation hardening techniques, electrical performance, total ionizing dose data, single event effects data, and single event upset error-rate calculations. The proton single event upset testing results will be shown at the conference. Since the heavy ion onset LET of the device is around 1 MeV-cm2/mg, the device is expected to be sensitive to protons [2]. Proton data, therefore, is critical to a comprehensive understanding of the SEU performance of the device.

7.0305 Integrated Magnetic Memory for Embedded Computing Systems

Kenneth J. Hass, Gregory Donohoe (University of Idaho); Yang-Ki Hong (University of Alabama); Byoung-Chul Choi (University of Victoria); Kelly DeGregorio, Richard Hayhurst (American Semiconductor, Inc.)

Presentation: Monday, March 5th, 6:30 pm, Lamar/Gibbon

This paper describes a new nonvolatile memory technology being developed for embedded computing. Based on a Magnetic Tunneling Junction cell, these devices will be integrated into a radiation-hard SOI CMOS process, to replace conventional flip flops and small on-chip memories. The embedded magnetic memory uses a pair of MTJs in a differential scheme.Each cell will be programmed by a single current pulse. The challenge is to design the cells and the programming structures to make efficient use of the magnetic field, and minimize programming current.

7.0306 Carbon Nanotube Based Memory Development and Testing

R.F. Smith, T.Rueckes, S. Konsek, J.W. Ward, D.K. Brock, B.M. Segal (Nantero)

Manufacturability of most electronic devices based on carbon nanotubes depends on the ability to place, manipulate, and control individual structures at the molecular level. This approach is problematic due to the precise placement and registration required thus making large scale manufacturing difficult if not impossible. A novel technique has been developed to overcome this hurdle, allowing CNT based nano-devices to be fabricated directly on existing production CMOS fabrication lines. This technique has been demonstrated in a Class 1 commercial fab.

7.04 Reconfigurable Computing System Technologies

Session Organizer: Ian Troxel, SEAKR Engineering, Inc.
Session Organizer: Jeremy Ramos, Honeywell DSES

7.0401 Field Programmable Processor Array: Reconfigurable Computing for Space

Gregory W. Donohoe, David Buehler, K. Joseph Hass, William Walker (University of Idaho); Pen-Shu Yeh (NASA Goddard Space Flight Center)

Presentation: Monday, March 5th, 9:45 am, Lake/Canyon

The Field Programmable Processor Array (FPPA) is a reconfigurable processor chip developed for NASA for high-throughput, low-power on-board processing of streaming data. The FPPA implements a synchronous dataflow computational model, with 16 on-board processing elements. Each processing element can perform multiplication simultaneously with addition/subtraction or logic operations, data path formatting, and data path switching. An integral microsequencer executes an internally-stored program. The chips can be tiled to extend the dataflow pipeline across multiple chips. A suite of support software includes a simulator, assemblers, and design entry tools. A prototype has been fabricated in a radiation-hard by design (RHBD) process.

7.0402 High Performance Dependable Multiprocessor II

John R. Samson, Jr. Gary Gardner, David Lupia (Honeywell Aerospace, Defense, Space Systems), Minesh Patel, Paul Davis, Vikas Aggarwal (Tandel Systems), Alan George (University of Florida), Zbigniew Kalbarczyk (University of Illinois), Raphael Some (Jet Propulsion Laboratory)

Presentation: Monday, March 5th, 10:10 am, Lake/Canyon

NASA's New Millennium Program commissioned the development of Dependable Multiprocessor (DM) technology for use in science and autonomy missions. The goal of the Dependable Multiprocessor project is to provide spacecraft/payload processing capability 10x – 100x what is available today, enabling heretofore unrealizable levels of science and autonomy. Dependable Multiprocessor development is continuing as one of the four selected ST8 flight experiments planned to be flown in 2009. This paper describes the Dependable Multiprocessor Technology, the technology validation experiments and demonstrations achieved to date, the plans for the TRL6 technology validation effort, and the plans for the TRL7 flight validation.

7.0403 Communications for Integrated Modular Avionics

Richard L. Alena (NASA), John P. Ossenfort IV (SAIC), Kenneth I. Laws (QSS), Andre Goforth (NASA) (NASA Ames Research Center); Fernando Figueroa (NASA Stennis Space Center)

Presentation: Monday, March 5th, 10:35 am, Lake/Canyon

The aerospace industry has been adopting avionics architectures to take advantage of advances in computer engineering. Integrated Modular Avionics (IMA), as described in ARINC 653, distributes functional modules into a robust configuration interconnected with a "virtual backplane" data communications network. Each avionics module's function is defined in software compliant with the APEX Application Program Interface. The Avionics Full-Duplex Ethernet (AFDX) network replaces the point-to-point connections used in previous distributed systems with "virtual links". This network creates a command and data path between avionics modules with the software and network defining the active virtual links over an integrated physical network.

7.05 Mixed Signal and System-on-a-Chip Technologies

Session Organizer: Nikolaos Paschalidis, The Johns Hopkins University - Applied Physics Laboratory

Session Organizer: Mark Martin, The Johns Hopkins University - Applied Physics Laboratory

7.0501 System-on-a-Chip Design of Self-Powered Wireless Sensor Nodes for Hostile Environments

David J. Barnhart, Tanya Vladimirova, Martin N. Sweeting (Surrey Space Centre)

Presentation: Thursday, March 8th, 9:15 pm, Jefferson

A new dimension of wireless sensor network architecture design is emerging where hundreds to thousands of ultra-light (<10 g) low-cost sensor nodes are required to collectively perform a spectrum of distributed remote sensing missions in hostile conditions, predominantly those encountered in space. Environmental extremes, such as mechanical, thermal, atmospheric, energetic, and dynamic must be considered. Research is underway to investigate the feasibility of fabricating survivable self-powered wireless sensor nodes monolithically with commercially available complementary metal-on-silicon technology. An example "SpaceChip" scenario is presented, where the conceptual design of a satellite-on-a-chip is explored.

7.0502 New Technologies and Concepts for Low Loss Radiation Hardened DC/DC Converters

Geoffrey Marcus (Johns Hopkins University Applied Physics Laboratory)

Presentation: Thursday, March 8th, 9:40 pm, Jefferson

The paper describes two new technology developments that simultaneously increase efficiency and radiation tolerance of radiation hardened DC/DC Converters. An extremely radiation hardened Pulse Width Modulator is described first which is shown to exhibit an order of magnitude smaller power consumption than existing state of the art components.

Secondly, a radiation hardened Digital Isolator is reported which uses capacitive coupling to transfer digital data across a galvanically isolated interface. TID and SEE results are given for both. A method for combining the two technologies to simultaneously improve radiation tolerance and power efficiency over current DC/DC converter technology is described.

7.06 Miniaturization and Advanced Electronics Packaging for Spacecraft

Session Organizer: Janet Lumpp, University of Kentucky
Session Organizer: Andrew Shapiro, Jet Propulsion Laboratory, Caltech

7.0601 Carbon Nanotube Filled Conductive Adhesives for Aerospace Applications

Jing Li, Janet Lumpp (University of Kentucky)

Presentation: Monday, March 5th, 4:30 pm, Lake/Canyon

Electrically conductive adhesives provide lead-free alternatives to solder in microelectronic assemblies. Multiwall carbon nanotubes dispersed in epoxy produce high electrical conductivity, improved thermal conductivity and maintain the mechanical strength of the matrix at low loadings. Carbon nanotube filled adhesives are lightweight, non-metallic, and lead-free. We present measurements of DC contact resistance, volume resistivity, AC scattering parameters, thermal diffusivity, and shear strength for a range of compositions.

7.0602 High-Density PWB Microvia Reliability for Space Application

Jamal Haque (Honeywell Aerospace)

Presentation: Monday, March 5th, 4:55 pm, Lake/Canyon

Microvias are used extensively in multi-layered PWB designs to interconnect high-density components with multi-layer board traces. Microvias are the next step in PWB evolution to reduce pad size, thus reducing trace size and increasing the number of traces in a given area of PWB. The paper examines the implication of putting microvia through intense thermal cycle's for their robustness in space.

7.0603 Multi-Functional Spacecraft Structures Integrating Electrical and Mechanical Functions

Donald V. Schatzel (Jet Propulsion Laboratory)

Presentation: Monday, March 5th, 5:20 pm, Lake/Canyon

Future earth orbiting, solar system and celestial body autonomous missions can benefit from spacecraft systems and instruments that have significantly lower weight and volume over current state of the art designs. Incorporating electronic traces or signal paths directly into the spacecraft or instrument structure can provide a significant savings in weight and volume. In addition, local computer processing power, increased operational speed and larger memory storage are achievable by using embedded or direct chip attach design methods. The objective of this technology development is to demonstrate the feasibility of electronic circuit boards that function as structural members within a subsystem.

7.07 Fault Tolerance, Autonomy, and Evolvability in Spacecraft Avionics

Session Organizer: Didier Keymeulen, Jet Propulsion Laboratory, Caltech
Session Organizer: Tom Hoffman, Jet Propulsion Laboratory, Caltech

7.0701 Automating the Pluto Experience: An Examination of the New Horizons Autonomous Operations Subsystem

Brian A. Bauer, W. Mark Reid (Johns Hopkins University Applied Physics Laboratory)

Presentation: Wednesday, March 7th, 8:30 am, Lake/Canyon

The long duration New Horizons mission requires high reliability and imposes demanding fault management requirements upon the spacecraft. The spacecraft is highly redundant with onboard software that provides a rule based expert system for performing autonomous fault detection and recovery, referred to as Autonomy. The Autonomy design was largely driven by the concept of operations for the mission and the level of redundancy in the spacecraft hardware. This paper discusses how the Autonomy system supports the various

phases of the mission. It examines the unique mission requirements that drove the Autonomy design and how these requirements were implemented.

7.0702 Autonomous Fault Protection Orbit Domain Modeling In Aerobraking

John Kenworthy, Eric Seale, Jason Dales (Lockheed Martin)

Presentation: Wednesday, March 7th, 8:55 am, Lake/Canyon

Aerobraking, the process of using atmospheric drag to dissipate orbital energy, for interplanetary spacecraft requires that the operations team adhere to many constraints in order to successfully achieve the desired orbit. The Mars Reconnaissance Orbiter team developed new capabilities to allow the spacecraft to configure itself autonomously in the presence of faults. The fault response architecture is designed to minimize required ground interaction by configuring the spacecraft for drag passes and, if necessary, performing a burn to get the spacecraft up and out of the atmosphere. This paper discusses the methodology and examples of the robustness of our approach.

7.0703 A Robust Fault Protection Strategy for a COTS-Based Spacecraft

Bill Jackson, SpaceDev, Inc.)

Presentation: Wednesday, March 7th, 9:20 am, Lake/Canyon

This paper presents a robust fault protection strategy for a low-cost single-string spacecraft that makes extensive use of COTS components. These components include commercial processors and microcontrollers that would traditionally be considered inappropriate for use in space. By crafting an avionics architecture that employs multiple distributed processors, and coupling this with an appropriate fault protection strategy, even a single-string COTS-based spacecraft can be made reasonably robust.

7.0704 Fault Injection Campaign for a Fault Tolerant Duplex Framework

Gian Franco Sacco, Robert D. Ferraro, Paul von Allmen, Dave A. Rennels (Jet Propulsion Laboratory)

Presentation: Wednesday, March 7th, 9:45 am, Lake/Canyon

In this work we present the results of a fault injection campaign we conducted on the Duplex Framework (DF). The DF is software that allows two copies of the same program to run on two different nodes of a commercial off-the-shelf computer cluster. A third process running on a different node constantly monitors the results computed by the two replicas, and instructs the DF to restart the two replica processes if an inconsistency is detected. In order to test the reliability of the DF we wrote a simple fault injector that injects faults in the virtual memory...

7.0705 Demonstration of Self-Training Autonomous Neural Networks in Space Vehicle Docking Simulations

M. Clinton Patrick, Katherine Chavis (NASA Marshall Space Flight Center); Steven Thaler (Imagination Engines, Inc.)

Presentation: Wednesday, March 7th, 10:10 am, Lake/Canyon

Neural Networks have been under examination for decades in many areas of research, with varying degrees of success and acceptance. Key goals of computer learning, rapid problem solution, and automatic adaptation have been elusive at best. This paper summarizes efforts at NASA's Marshall Space Flight Center harnessing such technology to autonomous space vehicle docking for the purpose of evaluating applicability to future missions.

7.0706 Fault-Tolerant 2D Fourier Transform with Checksum Encoding

Grzegorz Cieslewski, Adam Jacobs, Alan D. George (University of Florida)

Presentation: Wednesday, March 7th, 10:35 am, Lake/Canyon

One of the more common kernels in space-based applications is the 2D fast Fourier transform (FFT). Many papers have investigated fault-tolerant FFT, but no algorithm has been devised that would allow for error correction without re-computation from original data. In this paper, we present a new method of applying algorithm-based fault tolerance (ABFT) concepts to the 2D-FFT that will not only allow for error detection but also error

correction within memory-constrained systems. The performance of the fault-tolerant 2D-FFT will be presented and featured as part of a dependable range Doppler processor, which is a subcomponent of synthetic-aperture radar algorithms.

7.0707 Temperature-Adaptive Circuits on Reconfigurable Analog Arrays

Ricardo Zebulum, Adrian Stoica, Didier Keymeulen, Rajeshuni Ramesham (Jet Propulsion Laboratory); Joseph Neff (SPAWAR); Srinivas Katkoori (University of S. Florida)

Presentation: Wednesday, March 7th, 11:00 am, Lake/Canyon

This paper describes a new reconfigurable analog array (RAA) architecture and an integrated circuit (IC), and its use to map analog circuits that adapt to extreme temperatures. Evolution-driven adaptation takes place on the RAA IC, guided by algorithms implemented in a Field Programmable Gate Array (FPGA) collocated with the RAA in the extreme temperature environment. The experiments demonstrate circuit adaptation over a wide temperature range, from extremely low of -180°C to high of 120°C...

7.0708 Extreme Temperature Electronics Based on Self-Adaptive System Using Field Programmable Gate Array.

Didier Keymeulen, Ricardo Zebulum, Ramesham Rajeshuni, Adrian Stoica (Jet Propulsion Laboratory), Srinivas Katkoori (USF), Sharon Graves, Frank Novak, Charles Antill (NASA Langley Research Center)

Presentation: Wednesday, March 7th, 11:25 am, Lake/Canyon

Space missions often require radiation and extreme-temperature hardened electronics to survive the harsh environments beyond earth's atmosphere. Traditional approaches to preserve electronics incorporate radiation shielding, insulation and redundancy at the expense of power and weight. In this work, we report the implementation of a self-adaptive system using a field programmable gate array (FPGA) and data converters. The self-adaptive system can autonomously recover the lost functionality of a reconfigurable analog array (RAA) integrated circuit (IC) [3]. Both the RAA IC and the self-adaptive system are operating in extreme temperatures (from 120°C down to -180°C). The RAA IC consists of reconfigurable analog...

7.08 Electronics for Extreme Environments

Session Organizer: Mohammad Mojarradi, Jet Propulsion Laboratory, Caltech

Session Organizer: Elizabeth Kolawa, Jet Propulsion Laboratory, Caltech

7.0801 CMOS Compatible SOI MESFETs for Wide Temperature Range Electronics

T. J. Thornton, J. Ervin (RF Micropower Inc); A. Balijepalli, A. Shanmugam, W. Lepkowski, K. Holbert, B. Bakkaloglu (Arizona State University)

Presentation: Wednesday, March 7th, 4:30 pm, Lake/Canyon

A standard silicon-on-insulator SOI CMOS process has been used to fabricate metal-semiconductor field-effect transistors (MESFETs). The devices have excellent DC and small-signal transfer characteristics with device breakdown voltages greatly exceeding those of the CMOS devices. The DC parameters of the device were measured over the temperature range −196C to +150C and used to develop a TOM3 Spice model that accurately describes MESFET operation over the entire temperature range. We have used the model to demonstrate a number of SOI MESFET based circuits including an operational amplifier and a proportional-to-absolute-temperature (PTAT) voltage source.

7.0802 Development of a DC Motor Drive for Extreme Cold Environments

John Garrett, Roberto Schupbach, Alexander B. Lostetter (Arkansas Power Electronics International, Inc.), H. Alan Mantooth (University of Arkansas)

Presentation: Wednesday, March 7th, 4:55 pm, Lake/Canyon

This paper details the cryogenic testing of commercially available component technologies commonly used in DC motor drives to determine which could provide for feasible operation in an extreme cold environment. The components evaluated included: resistors, capacitors, gate drivers, transistors, diodes, and a DC motor controller. The performances of some

silicon carbide (SiC) devices (diode and transistor) when exposed to cold temperatures were also evaluated. Based upon the results of the testing a cryogenic 20 W full bridge power stage was built and tested.

7.09 Spacecraft Guidance, Navigation, and Control Technologies

Session Organizer: Anhtuan Ngo, U.S. Air Force Research Laboratory
Session Organizer: Michael Oppenheimer, U.S. Air Force research Laboratory
Session Organizer: James Luecke, L-3 Communications - IEC

7.0901 Analysis of the Reconfigurable Control Capabilities of a Space Access Vehicle

Michael W. Oppenheimer, Anhtuan D. Ngo, William B. Blake (Air Force Research Laboratory)

Presentation: Thursday, March 8th, 8:30 am, Lake/Canyon

Future access to space vehicles will be required to achieve a high level of safety and operability. In order to achieve these goals, integrated adaptive guidance and control can be used to recover a vehicle from off-nominal conditions, such as control effector failures, engine out, loss of engine gimbal, and so on. In this work, a preliminary configuration for a space access vehicle is defined. A guidance and control (G&C) design tool to rapidly assess the necessary control effort of the vehicle to track its flight trajectory is developed. Given the conceptual configuration and a desired trajectory for re-entry flight, this G&C tool provides an inner-loop feedback control law and outer-loop...

7.0902 Input Saturation Treatments: A Performance Comparison of Direct Adaptive Control and Theta-D Control

Quang M. Lam (Orbital Sciences Corporation); David T. Drake & D. Brett Ridgely (Raytheon); Missile Systems)

Presentation: Thursday, March 8th, 8:55 am, Lake/Canyon

Flight control saturation elements normally exist due to two main reasons: (1) physical limitations of actuator dynamics and (2) controller implementations to safeguard flight operations. Physical limitations or saturations are perceived as limited control authority of an actuator or the limited capacity of a torque producer device. However, saturation from the implementation standpoint commonly occurs due to safety reasons. In this paper, two adaptive control treatments, Direct Adaptive Control and μ-D control, are employed to ameliorate these nonlinear effects. The effectiveness of these adaptive treatments is then analyzed using Lyapunov function and Hamilton-Jacobi-Bellman optimization based principles.

7.0903 Precision Attitude Determination Using a Multiple Model Adaptive Estimation Scheme

Quang M. Lam (Orbital Sciences Corporation); John L. Crassidis (University at Buffalo)

Presentation: Thursday, March 8th, 9:20 am, Lake/Canyon

This paper is mainly motivated by three reasons: (1) future missions which will necessitate the employment of low cost and low grade Micro-Electro-Mechanical Systems (MEMS) sensors (e.g. MEMS gyros or compact star trackers) while still demanding a high precision attitude estimation, (2) development of a real-time noise statistics estimation capability in order to extend/enhance the performance of a traditional Kalman estimator whose performance is mainly dictated by the knowledge accuracy of its process noise and measurement noise covariance matrices, and (3) performance enhancement of a traditional 6 state Extended Kalman Filter (EKF) whose performance is drastically affected and compromised due...

7.0904 Terrestrial Attitude Estimation for the Formation Control Testbed

Joel Shields, Hannah Goldberg, Jason Kiem, Mauricio Morales, Dan Scharf (Jet Propulsion Laboratory)

Presentation: Thursday, March 8th, 9:45 am, Lake/Canyon

In this paper the problem of terrestrial attitude estimation of a unique robotic vehicle using attitude and inertial rate measurements is considered. The vehicle is completely

autonomous and uses air bearings to simulate the drag free dynamic environment of space. Stochastic models of the sensors and rigid body motion of the vehicle are developed for the purposes and estimator design and performance evaluation. We show a 3X reduction in the standard deviation of the attitude estimates by proper mixing of the two sensor measurements. The attitude estimation algorithm also provides bias free estimates of the angular rate.

7.0905 Decentralized Cooperative Navigation for Spacecraft

Joseph Nicosia (L-3 Communications)

Presentation: Thursday, March 8th, 10:10 am, Lake/Canyon

This paper describes a navigation technique called Decentralized, Cooperative Navigation (DCN) that uses a communications network with inter-node ranging to make use of the information from several satellites or other platforms to cooperatively navigate. Further, the computations are performed at each node, without the use of a central computing node, so that the network is robust, allowing nodes to enter and leave as they become available. Simulation results are presented which compare individual satellite navigation performance at Geosynchronous Orbit (GEO) with the navigational performance accuracy achieved at each node of a networked, small collection of nodes.

7.0911 Gyro Evaluation for the Mission to Jupiter

Sergei A. Jerebets (Jet Propulsion Laboratory)

Presentation: Thursday, March 8th, 6:30 pm, Lamar/Gibbon

Different gyro technologies and their critical performance characteristics are discussed, compared and evaluated to facilitate a choice of appropriate gyro-based inertial measurement unit to operate in a harsh Jovian environment to assure a successfull mission to Jupiter.

7.10 Large Space-Based Sensor Platforms

Session Organizer: Gerard Genello, U.S. Air Force Research Laboratory

7.1001 High Performance Space Computing

John W. Rooks, Richard W. Linderman (Air Force Research Laboratory/Information Directorate)

Presentation: Wednesday, March 7th, 5:20 pm, Lake/Canyon

This paper describes a fully programmable 6 processor die that was implemented in IBM's 130 nanometer 8SF process. It is capable of operating as two triple voted processors each with 6 Mbytes of Embedded Dynamic Random Access Memory (EDRAM) or 6 independent processors each with 2 Mbytes of EDRAM. The processor core with on-chip memory performs approximately 2.5 Giga Floating Point Operations Per Second (GFLOPS) per Watt. An example is given that applies numerous processors to a radar moving target indicator applicaton.

7.1002 Multiresolution Subspace Beam Formation Using a Partially Coherent Model

Robert J. Bonneau (US Air Force Research Laboratory)

Presentation: Wednesday, March 7th, 8:50 pm, Lake/Canyon

Traditional beam formation and waveform techniques rely on fixed apertures with single frequency assumptions that restrict the geometry of the aperture. This approach results in constraints on the functionality of radar systems such as having simultaneous imaging and tracking ability, elliminating complex interference, and working with platforms that have limted bandwidth and processing resources. We propose an adaptive multiresolution orthogonalized subspace beam formation method (AMOS) that allows optimization of apertures that may have non-uniform spacing with limited bandwidth. We combine this model with a partially coherent electromagnetic wavefront propagation model. We will show how this method compares to similar methods from a theoretical lower bound standpoint.

7.11 Advanced Spacecraft and Mission Concepts

Session Organizer: Scott Tyson, SES Consultants, Inc.
Session Organizer: John Samson, Jr., Honeywell Inc.

7.1101 Modular, Reconfigurable, High-Energy Technology Development

Connie Carrington, Joe Howell (NASA Marshall Space Flight Center)

Presentation: Monday, March 5th, 8:50 pm, Lake/Canyon

The Modular, Reconfigurable High-Energy Technology Demonstrator project would have been a series of ground-based demonstrations to mature critical technologies needed for in-space assembly of high-power modular cargo-transport vehicles. This paper presents an overview of Phase I activities at MSFC and its contractor partners. Lockheed Martin Advanced Technology Center developed a three robot-satellite ground demo of rendezvous & docking, self-assembly, reconfiguration, and boom deployment. ENTECH provided material recommendations for radiation-hardened concentrator lenses, and test results for a hi-voltage PV receiver. UAH performed tests on Supertube heat-pipes, and MSFC and Boeing performed systems trades and developed preliminary concept designs.

7.1102 Optimization of Inner Heliospheric Sentinels Spacecraft Conceptual Design

Richard F. Conde, Kenneth A. Potocki, Karen W. Kirby, Paul B. Adamsen, Robert S. Bokulic, George Dakermanji, Wayne F. Dellinger, Carl J. Ercol, Karl B. Fielhauer, Jeff S. Kelley, Binh Q. Le, W. Jeffrey Lees, Barbara A. Leary, Sharon X. Ling, Perry M. Malouf, David H. Napolillo, David F. Persons, John R. Troll, Robert E. Wallis (Johns Hopkins University Applied Physics Laboratory); Adam Szabo, Haydee Maldonado, John P. Downing, David C. Folta, Greg Marr (NASA Goddard Space Flight Center); Robert P. Lin (University of California, Berkeley); William S. Lewis (Southwest Research Institute)

Presentation: Monday, March 5th, 9:15 pm, Lake/Canyon

The Sentinels mission is a key component of NASA's "Living With a Star" program. The Sentinels Science and Technology Definition Team have completed a study to define the science objectives, measurement requirements and observational strategies, and mission design of the Inner Heliospheric Sentinels (IHS). The four spin-stabilized IHS spacecraft are in elliptical heliocentric orbit with perihelia at 0.25 AU and aphelia at 0.75 AU. This orbit presents unique spacecraft thermal control and power challenges. This study has demonstrated mission feasibility by developing a spacecraft design concept using conventional technologies. Numerous trade studies were performed to optimize the spacecraft design.

7.1103 Artificial Gravity for Space Travel

Shun-Wen Cheng (Far East University, Taiwan)

Presentation: Monday, March 5th, 6:30 pm, Lamar/Gibbon

This study presents magnetic concepts for artificial gravity and artificial balance on space travel. The magnetic pseudo gravity system could be constructed on any size manned spacecraft, low-gravity planet and moon. Qualitative analysis of the magnetic methods via soft ferrite, Fe oxide nano-particles and ferrofluids is elucidated. The magnetic method could ensure that weight-bearing bones of space travelers are continually under stress and that the osteoblast cells will be formed. The coated Fe oxide nanoparticle and ferrofluids could enable the inner ear balance mechanism. The proposed magnetic methods could effectively construct artificial gravity and artificial balance for space travel.

7.12 Avionics to Support Contemporary Commercial and Space Tourism Ventures

Session Organizer: Scott Tyson, SES Consultants, Inc.
Session Organizer: David Czajkowski, Space Micro, Inc.